

Anatomy and systematics of a new species from China, *Aegista laoyelingensis* (Stylommatophora; Bradybaenidae)

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Abstract: This paper describes a new species of pulmonate land snail, *Aegista laoyelingensis*, from Jilin Province, Northeastern China. The shell of this gastropod is small, light brown, unbanded, and has a rough surface. Whorls number about 5.5 ± 0.1 ; the last whorl is never keeled. *Aegista laoyelingensis* has a short epiphallus, but lacks a flagellum. This species has a unique pattern of fusion of the central nervous system, and there is variation in mantle pigmentation.

The Bradybaenidae are a large, widespread family of pulmonate land snails with a distribution centered in Southeast Asia but ranging to Europe and North America. The Bradybaenidae comprise the following subfamilies: Aegistinae Kuroda and Habe, 1951; Bradybaeninae Pilsbry, 1924; Euhadrinae Minato, 1988; Helicostylinae Ihering, 1909; and Monadeniinae Nordsieck, 1987 (see Miller and Naranjo-Garcia, 1991). Over 80 genera and subgenera are involved (Richardson, 1983). The species of *Aegista* are common snails distributed in China, Japan and nearby Islands. There are about 33 Chinese species of *Aegista* described by Heude (1882), Tryon (1888), Pilsbry (1895), Wiegmann (1900), Yen (1939), Chen and Gao (1987). Unfortunately, these authors based their descriptions solely on shell characters; they did not supply anatomical data. The purposes of the paper are: (1) to describe a new species from Northeastern China, *Aegista laoyelingensis*, and present the detailed anatomy of the new species; (2) to document the variation in mantle pigmentation; (3) to discuss the classification of the Aegistinae.

MATERIALS AND METHODS

Specimens were collected from a small area of Laoyeling (Mountains), Jilin Province, the People's Republic of China, kept in jars filled with fresh leaves, and brought back to the laboratory of Northeast Normal University. After 5 hr, the living snails were drowned in distilled water for about 24 hr and allowed to fully extend. The specimens were fixed in 95% ethanol for about 1 hr, and

then transferred to, and preserved in, 70% ethanol. Five adults of the alcohol-preserved specimens were dissected, and organs measured at the Academy of Natural Sciences of Philadelphia, using a Wild M5A dissecting microscope. Scanning electron microscope studies on the radula were done at Northeast Normal University, and photographed with a Hitachi scanning electron microscope. The internal structure of the penis, ganglia and mucous gland were observed by cutting and opening the outside wall surrounding these organs. Institutional abbreviations are as follows: ANSP, Academy of Natural Sciences of Philadelphia; NNUC, Northeast Normal University of China.

SYSTEMATICS

Family: Bradybaenidae Pilsbry, 1934

Genus: *Aegista* Albers, 1850

Aegista laoyelingensis Zhang sp. nov.

Type locality. Laoyeling (Mountains), Tiangang commune, Panshi County, Jilin Province, the People's Republic of China, 43.20° N, 127.40° E, on the bottom of a hill close to a railway station (about 2.5 km to the North of the station) elevation between 700 and 800 m.

Specimens were collected by the author on 16 July 1987. Habitat for the snails was a narrow area between a small stream and a trail. The main vegetation of the habitat was composed of the following trees: *Quercus*, *Populus*, *Juglans* and *Acer*; and bushes: *Corylus*, *Eleutherococcus* and *Lepedeza*. *Aegista laoyelingensis* preferred to crawl on the tops of bushes, with most snails collected from the leaves of *Corylus* and *Juglans* growing beside the stream.

Etymology. Named for the Mountains.

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MORPHOMETRICS

Holotype: shell height, 6.6 mm; shell diameter, 13.1 mm; whorls 5.6. (Fig. 1, NNUC 87001, preserved at the Institute of Zoology, Academia Sinica, Beijing, China.)



Fig. 1. Three views of holotype of *Aegista laoyelingensis*.

Paratype 1: shell height, 7.1 mm; shell diameter 14.3 mm; whorls 5.6, NNUC 87002.

Paratype 2: shell height, 6.3 mm; shell diameter 12.5 mm; whorls 5.5, ANSP 391682.

Paratype 3: shell height, 6.5 mm; shell diameter 12.9 mm; whorls 5.6, (in author's collection).

Paratype 4: shell height, 5.6 mm; shell diameter 11.1 mm; whorls 5.6, ANSP 391683.

DESCRIPTION

Shell. Shell small, depressed, with an open umbilicus, about 1/5 of shell diameter; shell light, somewhat thin, but solid; semitranslucent, uniformly light brown, not banded, whorls 5.6, surface often roughened by irregular growth lines. Spire low, with horn-colored apex, and with distinctly impressed suture. Body whorl not keeled or angulated, quite large in proportion; descending anteriorly. All whorls visible in the umbilicus and internal sutures deep. Aperture lunar, the peristome thin, colorless and toothless; narrowly reflexed at base.

Mantle. Mantle cavity length 26.9 mm. Mantle colors of holotype and paratype 1, 3 and 4 are lightly colored form, there is no pigmentation from the collar to the epithelium covering the uppermost part of the kidney (Fig. 2A). Variation in mantle pigmentation was found in paratype 2. The mantle is dark, the speckled melanin pattern can extend to the epithelium covering the uppermost part of the kidney (Fig. 2B).

Radula. Radula formula (from two individuals) is:
23-10-1-10-23 . (1 central tooth; 10 lateral teeth;
 68 23 marginal teeth; 68 rows)

Each central tooth consists of two distinctly pointed cusps (Fig. 3b: 1). There is one cusp on the outside edge of

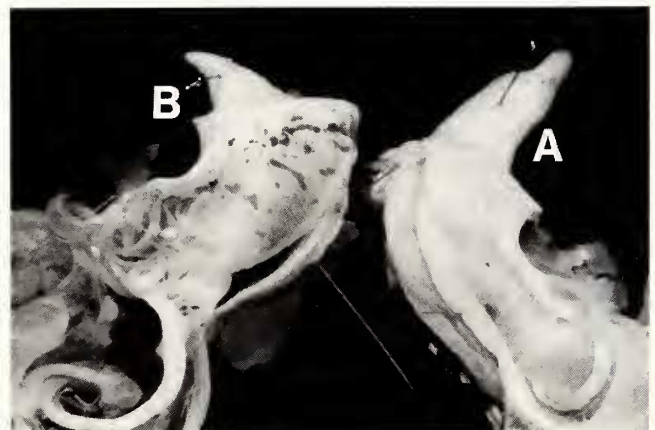


Fig. 2. Variation in mantle pigmentation. A, light form; B, dark form (speckled form).

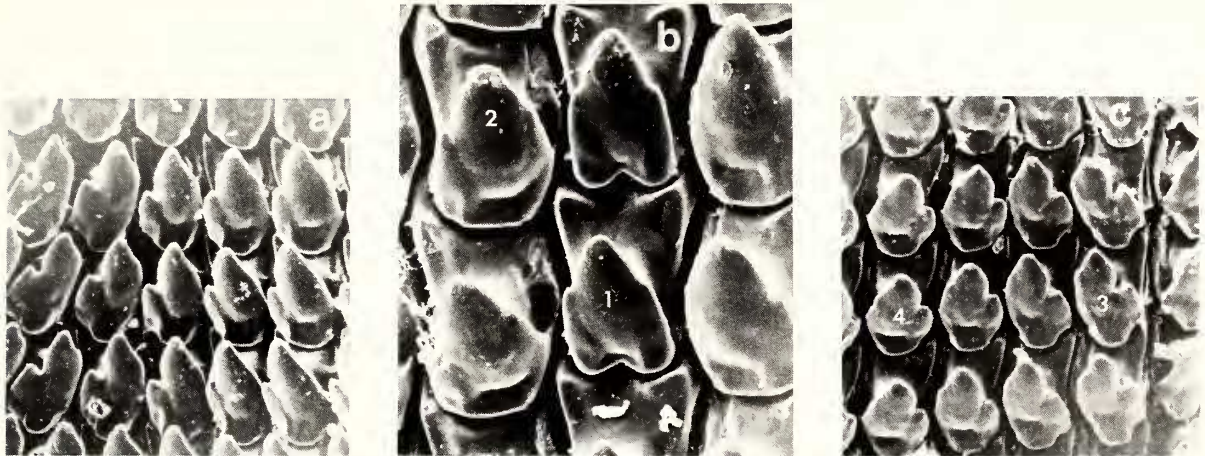


Fig. 3. Radula of *Aegista laoyelingensis*. a, left marginal teeth; b, (1) a central tooth; (2) a left lateral tooth; c, (3) a right marginal tooth; (4) a right lateral tooth.

each lateral tooth, but the inside edge is evenly rounded (Fig. 3b: 2). There is a gradual change in tooth form from the lateral teeth to marginal teeth. The distinction of marginal teeth from the lateral teeth can be described by the following characters: (1) the marginal teeth are longer than the laterals (Fig. 3c, 4), (2) the cusp on the outside edge of each marginal tooth (Figs. 3a and 3c: 3) has a sharper point than each lateral tooth does.

Digestive system. Major features are shown in figure 4: (1)

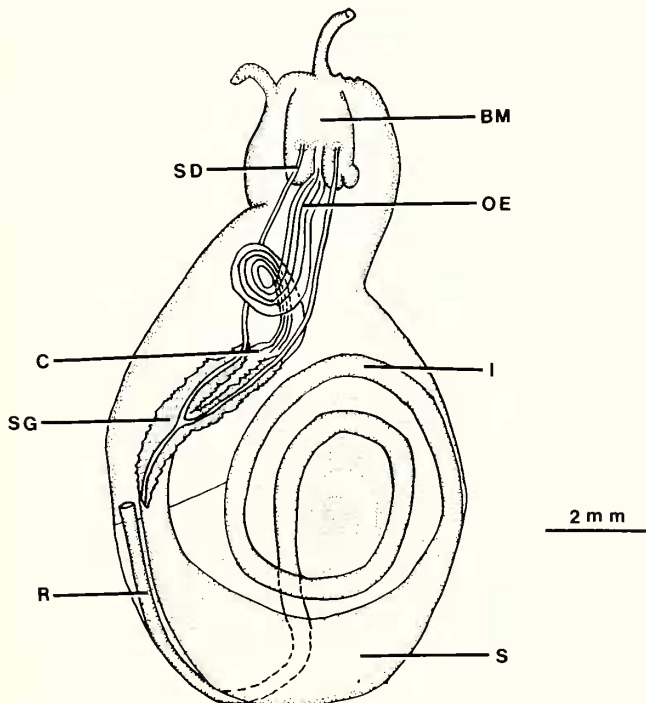


Fig. 4. Digestive tract of *Aegista laoyelingensis*. BM, buccal mass; C, crop; I, intestine; OE, oesophagus; R, rectum; S, stomach; SD, duct of salivary gland; SG, salivary gland.

the oesophagus (OE) is distinctly separated from the crop (C); (2) cylindrical crop widens from the oesophagus to the stomach (S); (3) intestinal loop is long, reaching the level of the distal limit of the crop; (4) internal morphology shows 6-7 unciliated ridges run from the upper end of the oesophagus into the stomach.

Reproductive system. The reproductive tract is shown in figure 5. Major features are: (1) two mucous glands (M) connect to an accessory sac (AC) along with the dart sac (DS). There is a sharp, calcified dart (dotted line, Fig. 5, DS), about 1.2-1.3 mm long (Fig. 7); (2) each mucous gland is hollow, and the gland cavity (GC) is surrounded by a thick and wrinkled wall. (Fig. 6: W); (3) flagellum absent; (4) a short epiphallus [Fig. 5: E, (3.4 mm long)] cannot be distinguished from the penis externally, the differences only

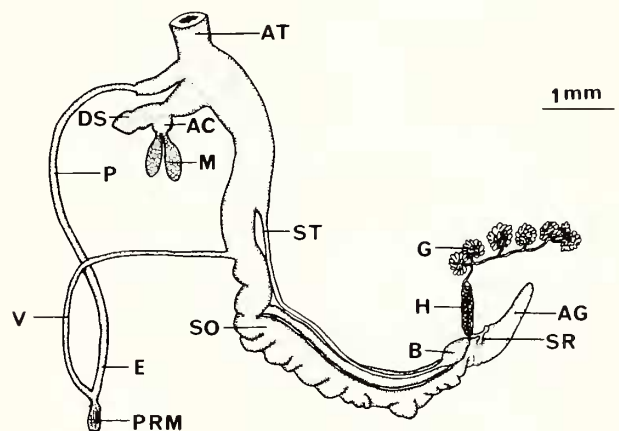


Fig. 5. Reproductive system of *Aegista laoyelingensis*. AC, accessory sac; AG, albumen gland; AT, atrium; B, bursa copulatrix; DS, dart sac; E, epiphallus; G, gonad (ovotestis); H, hermaphroditic duct; M, mucous gland; P, penis; PRM, penial retractor muscle; SO, spermooviduct; SR, seminal receptacles; ST, stalk of bursa copulatrix; V, vas deferens.

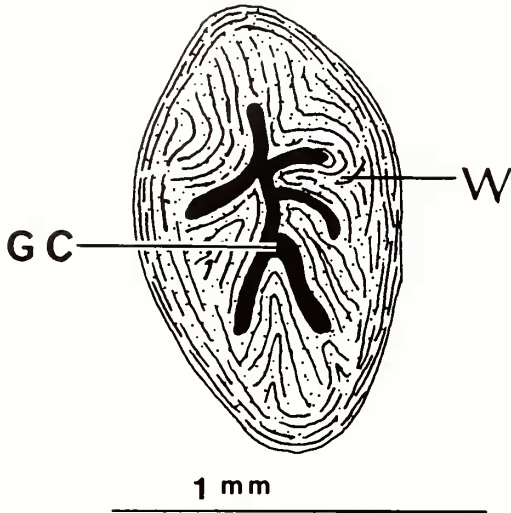


Fig. 6. Cross section of a mucous gland of *Aegista laoyelingensis*. GC, gland cavity; W, wall of the cavity.

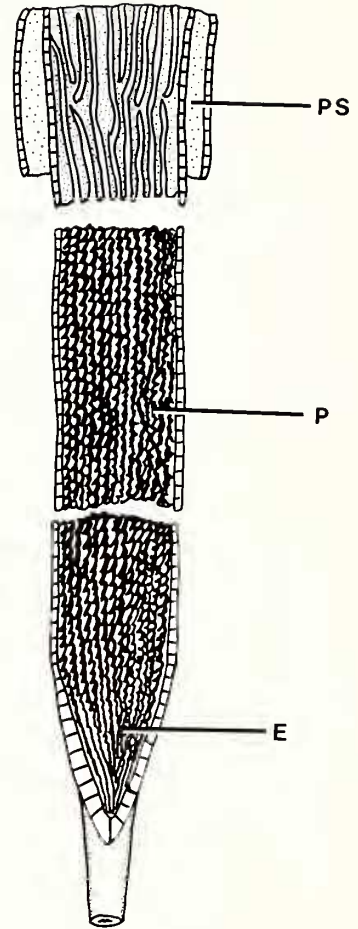


Fig. 8. Internal morphology of the penis. E, epiphallus; P, penis; PS, penis sheath.

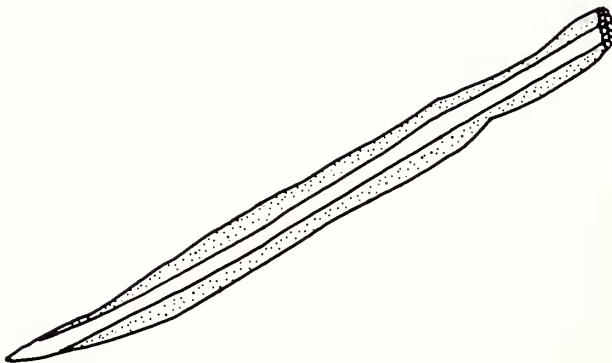


Fig. 7. Dart of *Aegista laoyelingensis*.

can be seen by cutting and opening the penial wall; (5) internal morphology of the epiphallus shows 7-8 longitudinal ridges (Fig. 8: E); (6) penis (P) has longitudinal radiating rows of pustules, lower portion of the penis has anastomosing longitudinal ridges, but without verge and penial pilaster (Fig. 8); (7) spermiduct (SO) length is about 21.8 mm; duct of bursa copulatrix (ST) length is 14.4 mm.

Central nervous system. The central nervous system is shown in Figure 9. The features are: (1) the length of cerebral ganglia (CG) are about 2.0 mm; (2) the length of the cerebral commissure (CC) is about 1.4 mm; (3) the length of the cerebral-pedal connective (CPC) is about 6.1 mm; (4) the length of the cerebral-pleural connective (CPLC) is about 7.6 mm; (5) the right pleural (RPL) and the right parietal ganglia (RPA) are completely fused, the fused

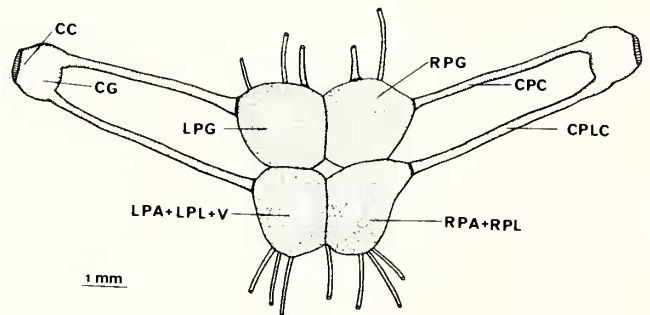


Fig. 9. Central nervous system of *Aegista laoyelingensis*. CC, cerebral commissure; CG, cerebral ganglia; CPC, cerebral-pedal connective; CPLC, cerebral-pleural connective; LPA+LPL+V, left parietal ganglion and left pleural ganglion plus visceral ganglion completely fused; LPG, left pedal ganglion; RPA+RPL, right parietal and right pleural ganglia fused; RPG, right pedal ganglion.

ganglion is about 1.6 mm long; (6) the left pleural (LPL) and the left parietal ganglia (LPA) plus the visceral ganglion (V) are completely fused, the fused ganglion is about

1.6 mm long.

Comparisons. I compared *Aegista laoyelingensis* with the published species from China (Table 1) and the collections of *Aegista* at the ANSP, National Museum of Natural History, Washington D. C., and Institute of Zoology of Beijing (Heude Museum) (China). I also compared this

species with some more recently described species of *Aegista* from Japan (Kuroda and Habe, 1951; Habe, 1957; Azuma, 1970; Sorita, 1980; Ogaito and Sorita, 1981; Azuma and Azuma, 1982; Sakurai and Sorita, 1982; Minato, 1983; Minato, 1988). I list the following characters to distinguish *Aegista laoyelingensis* from all other known

Table 1. Comparisons among *Aegista laoyelingensis* and the published species from China.

Species (Author)	# of Whorls	Diam. (mm)	Diagnostic characters	Surface	Peristome
<i>Aegista oculus</i> (Pfeiffer)	8	25	Periphery subangular, white banded	Rugosely plicate	Subangulately reflected, white and thin
<i>A. chinensis</i> (Philippi)	8	25	Last whorl slowly increasing	Shining	White, sublabbiate
<i>A. vermes</i> (Reeve)	8	32	Last whorl scarcely deflected in front, periphery subangular	Shining, with a white line	Whitish
<i>A. pseudochinensis</i> (Möllendorff)	8	27	Last whorl a little deflected	Shining	Reddish widely reflected
<i>A. herpestes</i> (Heude)	7	22	Last whorl obsoletely angulated	Whitish band	White, narrowly reflected
<i>A. furtiva</i> (Heude)	6	19	Last whorl narrow, with obsoletely angulated periphery	Slightly impressed suture	White, expanded
<i>A. aubryana</i> (Heude)	7	21	Periphery obtusely angulated, deflected in front	Brownish white	White and thin
<i>A. accrescens</i> (Heude)	7	16	Last whorl obtusely angulated	With a whitish band	White, narrowly reflected
<i>A. alphonsi</i> (Deshayes)	7	9	Last whorl a little deflected, obtusely angulated above	Irregularly punctate	Thick, sinuous, reflected
<i>A. platyomphala</i> (Möllendorff)	7	17.5	Last whorl obtusely angulated above	Well impressed suture	Thick and white
<i>A. subchinensis</i> (Möllendorff)	7	17	Last whorl scarcely descending in front, subangulated on the periphery	Shining, with a narrow white band	Thick and white
<i>A. initialis</i> (Heude)	6	12	Last whorl with obtuse white banded peripheral angle	Minutely striate	White, sinuous and thick
<i>A. serpestes</i> (Heude)	7.5	16	Last whorl with obsoletely angulated periphery	Shining	White and thick
<i>A. hupeana</i> (Gredler)	6.5	13-17	Last whorl with angulated periphery	Somewhat shining	Broadly expanded, thick
<i>A. permellita</i> (Heude)	7.5	19	Last whorl keeled	Slightly impressed suture	White
<i>A. tenerrima</i> (Möllendorff)	6	18	Last whorl with subangulated periphery	Slightly impressed suture	White and thick
<i>A. virilis</i> (Gredler)	7	15	Last whorl with obtusely angulated periphery	Shining	Little expanded
<i>A. laurentii</i> (Gredler)	4.5	11	Last whorl large	Shining	Not reflexed
<i>A. radulella</i> (Heude)	6	13	Last whorl with obtusely angulated periphery	Wart-like scales	Acute
<i>A. aranaeetela</i> (Heude)	5	9	Last whorl widely umbilicated	Strongly costate	Acute
<i>A. puberosula</i> (Heude)	8	10	Last whorl with obtusely angulated periphery	Minute granulous scales	Little reflected
<i>Plectotropis cathcartae</i> (Reeve)	6	27	Periphery compressly carinated	Reddish corneous	White
<i>P. mackensii</i> (Adams & Reeve)	6.5	30	Periphery acutely carinated	Hairy	Expanded above, thin
<i>P. gerlachi</i> (Möllendorff)	6	19-21	Last whorl with hairy carina	Suture superficial	Simple, a little reflected below
<i>P. lacinosula</i> (Heude)	6	30	Periphery acutely carinate	Hairy	White, slightly expanded
<i>P. trichotropis</i> (Pfeiffer)	6.5	17	Last whorl with acute ciliated periphery	Slightly impressed spiral lines	Simple, a little expanded above
<i>P. mellea</i> (Pfeiffer)	5	22	Periphery carinated	Shining	White, narrowly expanded above
<i>P. tapeina</i> (Benson)	6	15.5	Last whorl descending in front	Thread-like suture	White, dextrally a little expanded
<i>P. hupensis</i> (Gredler)	6.5	20	Last whorl not descending in front, base convex, subangulated, around the umbilicus	Brownish above, whitish-rayed below	White
<i>P. shanghaiensis</i> (Pfeiffer)	7	13	Last whorl not descending, periphery carinated	Shining	Subreflected, simple
<i>P. barbosella</i> (Heude)	6.5	15	Last whorl obsoletely angulated	Shaggy epidermis	Little thick
<i>P. Diploblepharis</i> (Möllendorff)	5.5	11.5	Last whorl keeled	Shining	White and thick
<i>P. submissa</i> (Deshayes)	4.5	11	Periphery angulated	Smooth	Thick and white

species in the genus:

1. Shells small (diameter = 13.0 ± 1.1 mm) in size for the genus (diameter range for the larger congeners is 15-32).

2. Whorls number 5.5 ± 0.1 ; last whorl never keeled or angulated, shell surface rough.

3. Flagellum absent (an important character to distinguish the new species from these published species in Japan). Other congeners have either a long or short flagellum (*A. trochula* Adams, 1868; *Aegista kandai* Azuma, 1970; *A. tokyoensis* Sorita, 1980; *A. nunobikiensis* Ogaito and Sorita, 1981; *A. hakusanensis* Azuma and Azuma, 1982; *A. itoi* Kuroda and Azuma, 1982; *A. kamuriyamensis* Azuma and Azuma, 1982; *A. tokyoensis choshiensis* Sakurai and Sorita, 1982; *A. tadaï* Minato, 1983).

The shell of *Aegista laoyelingensis* most closely resembles in shape that of *A. furtiva* Heude, 1885, from Southwestern China; but the latter shell is larger (diameter, 19 mm), the surface smoother, the peristome white, thicker and more widely reflected, and the last whorl has an obsoletely angulated periphery.

DISCUSSION

Minato (1988) listed more than 70 species and subspecies of *Aegista* from Japan and nearby islands. Kuroda and Habe (1951) placed the genus *Aegista* in the subfamily Aegistinae, based on different characters of shells and genital organs (such as, snails with more or less strongly developed flagellum). Their classification follows (see Habe, 1955):

Family: Bradybaenidae

Subfamily: Aegistinae

Genus: *Aegista* Albers, 1850

Subgenera:

Aegista Albers, 1850. Type species: *Aegista chinensis* (Philippi, 1845).

Plectotropis Martens, 1860. Type species: *Plectotropis elegantissima* (Pfeiffer, 1849).

Coelorous Pilsbry, 1900 (in *Coccolypta* Pilsbry 1900, see Richardson, 1983). Type species: *Coccolypta cavicollis* (Pilsbry, 1900).

Buliminopsis Heude, 1890 (in *Pseudobuliminus* Gredler, 1886, see Richardson, 1983). Type species: *Pseudobuliminus buliminoides* (Heude, 1882).

Trishoplita Jacobi, 1898 (placed in Bradybaeninae, see Richardson, 1983). Type species: *Trishoplita pallens* (Jacobi, 1898).

Nesiohelix Kuroda and Emura, 1943 (placed in Bradybaeninae, see Richardson, 1983). Type species: *Nesiohelix caspari* (Möllendorff, 1884).

Bradybaenid shells are variable in form (ranging from globose to depressed or lens-shaped), and in color pattern (from uniformity to many banded). For this reason Pilsbry (1895) listed some anatomical characters (but in his paper, the external anatomy and genitalia for *Aegista* were unknown) for distinguishing different genera of the Bradybaenidae. He concluded that *Plectotropis*, *Mastigeulota* and *Euhadra* possess a flagellum. The other genera lack it, probably by degeneration. It is likely that the degeneration had occurred in some Asian species grouped in *Aegista* too, such as the species reported by Wiegmann (1900): *Plectotropis diplolepharis* Möllendorff, 1902; *P. submissa* Deshayes, and *Aegista laoyelingensis*. The flagellum of these species is almost always lacking. Accordingly, it appears that the classification of the Aegistinae by Kuroda and Habe cannot be accepted prior to a complete revision in *Aegista*.

I agree with Nordsieck (1987) that the Asian Bradybaenidae (with stimulatory organ consisting of a dart sac, usually with an accessory dart sac and one or two dart glands) represent (in contrast to the American or the European Helicoidea) a strikingly consistent group, that cannot be arranged into subfamilies. For the Bradybaeninae species (distributed in Eastern Asia), they have the stimulatory organ with two dart glands that are usually divided. Since the different groups from Japan do not differ in the structure of the stimulatory organ (see Azuma, 1970; Sorita, 1980; Ogaito and Sorita, 1981; Azuma and Azuma, 1982; Kuroda and Azuma, 1982; Sakura and Sorita, 1982; Minato, 1983), there is no reason to divide Bradybaeninae into more subfamilies. Only the groups distributed in the Philippines can be separated based on the structure of its stimulatory organ (stimulatory organ with one simple dart gland), as the subfamily Helicostylinae.

Mantle pigment patterns are variable in *Aegista laoyelingensis*. Cain (1971) gave a detailed description of mantle polymorphisms in *Monacha cantiana* (Montagu) and demonstrated that mantle color is genetically controlled. Because the specimens used in my research were collected from a population in a habitat with the same environmental factors (temperatures and vegetation), the variation of mantle pigmentation could be caused by genetic mutations.

ACKNOWLEDGMENTS

This study was supported by a Jessup Award from the ANSP. Part of the field work was supported by a grant from Northeast Normal University. I am indebted to Drs. G. M. Davis, K. C. Emberton, R. Robertson, G. Rosenberg and A. Schuyler, and two anonymous reviewers for reading and

criticizing the manuscript. I am thankful to the following museums and curators for the use of their collections: Dr. G. M. Davis (Department of Malacology, ANSP); Dr. R. S. Houbrick (Division of Mollusks, National Museum of Natural History, Washington D. C.); Drs. Y. Y. Liu and D. N. Chen (Heude Museum, Institute of Zoology, Academia Sinica, Beijing). I hereby express my thanks to the following people for their helpfulness in my research: M. A. Garback, C. Hesterman, A. Bogan, H. Robertson, A. L. Hu and D. Z. Jing.

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Date of manuscript acceptance: 2 February 1993